Free Body Diagrams & Tension

October 10, 2017 12:28 PM

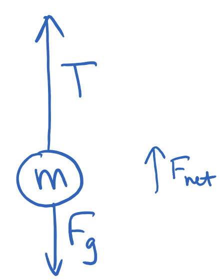
- Objects connected together often act as one system
  ie. the acceleration of all objects in the system is the same.
- Calculate acceleration from $F_{net} = m_{total} \cdot a$
- "Tension" = the force being applied to that object

Typical problem types:

$F_{net} = F_{applied} - F_{against}$

1. Object thrown up into the air:

- consider the throwing force to be T (applied force)
- remember $F_g = mg$
- Free Body Diagram (F.B.D.)



$F_{net} = F_{applied} - F_{against}$

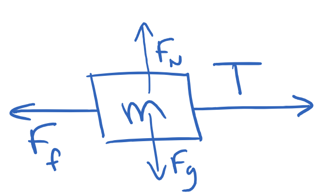
$F_{net} = T - F_g$

$ma = T - mg$

↑ accel of ball after F_g is taken off of the force of the throw (T)

2. Object pushed/pulled along table:

- consider push/pull to be T (applied force)
- remember $F_f = \mu F_N$ ($F_N = F_g$ if no angles involved)
- FBD

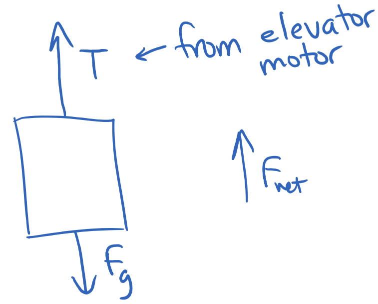


$$F_{net} = F_{applied} - F_{against}$$
$$ma = T - F_f$$
$$ma = T - \mu F_N$$
$$ma = T - \mu mg \quad \text{(since flat table)}$$

↑ accel of box after considering friction.

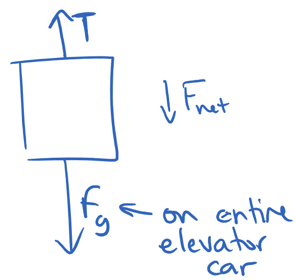
3. Elevators:

a) going up:



$$F_{net} = F_{appl} - F_{against}$$
$$\underset{\substack{ma \\ (up)}}{F_{net}} = T - F_g$$

b) going down:

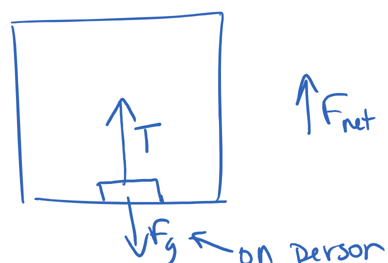


$$\underset{\substack{ma \\ (down)}}{F_{net}} = F_g - T$$

c) on bathroom scale:

(going up)

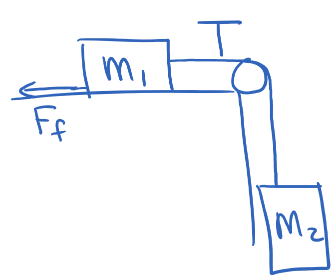
T is the scale reading (applied force)



$$F_{net} = T - F_g$$

4. Two objects connected:

a) Table edge:



only m_2 causes motion of system

to get "a":

$$F_{net} = F_{app} - F_{ag}$$
$$F_{net} = F_{g2} - F_{f1}$$

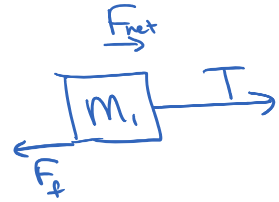
$$F_{f1} = \mu F_N$$
$$= \mu m_1 g$$

$$F_{net} = F_{g2} - F_{f1} \qquad F_{f1} = \mu F_N$$
$$(m_1+m_2)\,a = m_2 g - \mu m_1 g \qquad = \mu m_1 g$$

$\uparrow$ solve

to get "T":

F.B.D.

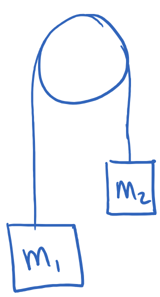


$$F_{net} = T - F_f$$
$$m_1 a = T - \mu m_1 g$$

$\uparrow$ solve

b) over pulley:

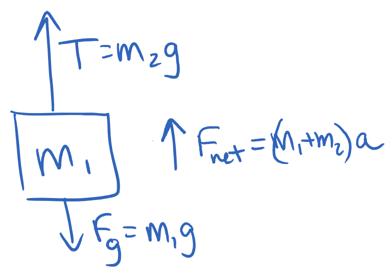
if unequal masses, then will accelerate, one up (+) and one down (−)



to find "a":

(if m_2 larger)

FBD



$$F_{net} = T - F_g$$
$$(m_1+m_2)\,a = m_2 g - m_1 g$$

$\uparrow$ solve

General

- used $g = +9.8\,\frac{m}{s^2}$ so we could subtract off as is intuitive to do.
- constant speed (can be zero) means $a = 0$ so $F_{net} = 0$
- if angles are involved, calculate the needed component

- if angles are involved, calculate the needed components
- Kinematics may be involved $d = v_{avg} t$
  $v_f = v_0 + at$
  $d = v_0 t + \frac{1}{2}at^2$
  $v_f^2 = v_0^2 + 2ad$
- remember $F_{net} = F_{applied} - F_{against}$

Practice pg 72 #1-3 $F=ma$
pg 73 # 1-2
pg 77 # 1-6